Mathematics and Statistics

Faculty of Arts and Science
COURSE GUIDE

2000-2001

Concordia
UNIVERSITY

DEPARTMENT OF MATHEMATICS AND STATISTICS

COURSE GUIDE 2000-2001

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This course guide has been prepared months in advance of the 2000-2001 academic year and information contained herein is subject to change.

1. INTRODUCTION TO THE DEPARTMENT

Main Objective

The Department of Mathematics and Statistics' main objective is to communicate to students both the beauty and the practical usefulness of mathematics. We convey to our students an understanding of the broad outlines of actuarial mathematics, pure and applied mathematics, and statistics to prepare them for jobs in industry and business where mathematics is playing an increasingly important role, and to stimulate their interest in research.

Programme Objectives

The courses offered by the Department foster mathematical thinking and reasoning, developing general problem-solving skills that are an asset to students throughout their career. The Department has embraced the changes manifested in computer technology and educational reform, enriching the learning and intellectual environment. Our flexible yet challenging undergraduate programmes cater to the diverse interests of students who plan to make mathematics their career as well as to those who will use mathematics in other fields.

Faculty

As a student at Concordia, you will have direct access to dynamic faculty members who will help you through the programme of your choice. The faculty is not only dedicated to teaching, but many are at the forefront of research in such areas of mathematics as chaos theory, dynamical systems, mathematical physics, number theory, risk theory, and statistics. They publish extensively in outstanding journals, compete successfully for research funding, present papers at national and international conferences, and actively supervise graduate students.

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2. COMPUTER LABORATORIES

The Department has computer laboratories equipped with UNIX workstations, Pentiums, and 486 machines. Available software include symbolic mathematics programmes (MAPLE, Mathematica), statistical packages (S-Plus, SPSS), internet browsers (Netscape, Explorer), spreadsheets (Excel), mathematical typesetting systems (TeX, Scientific WorkPlace), word processing programs (MSWord, WordPerfect), and compilers (C++, Fortran). All computers have direct internet connections and access to high-quality laser printers. The Undergraduate and Graduate labs. (L-HB 224/226) are open to students in Mathematics & Statistics; the CICMA Lab. (S-LB 522) is opened to graduate students only.

3. ADMISSION REQUIREMENTS

The enrolment in the Specialization programme is on a selective basis (based on students' overall academic achievements), whereas the Major is open to all students. However, students with less than 70% average in CEGEP mathematics courses are required to take a "transition" calculus and linear algebra course (MAST 214) as a requirement outside their programme.

Application to the Honours program is only possible once a student has completed between 30 to 60 credits in the Specialization programme (aproximately one year), and has at least a B average with no course grades under a C-. Usually, the student will be invited by their academic advisor to join the Honours programme. In addition to having the obligation of satisfying the University's Honours regulations (See Section 16.2.3 of the Undergraduate Calendar), the student will be required to complete a 6-credit project during their final year, under the supervision of their academic advisor.

4. THE GRADING SYSTEM

These grades are approximate and are only used for the Mathematics & Statistics Department.

90-100	A+	70-72	B-	53-56	D
85-89	A	67-69	C+	50-52	D-
80-84	A-	63-66	C	F/DNW	Fail/Did Not Write
77-79	B+	60-62	C-	Blank	No record of student
73-76	B	57-59	D+		

5. THE UNDERGRADUATE PROGRAMMES

The Honours/Specialization Programmes

Actuarial Mathematics
This area is designed for students with a keen interest in mathematics who wish to have a career as an actuary, or who may wish to pursue graduate studies. While providing a thorough mathematical background, this field prepares the student for the joint examinations of the Society of Actuaries or the Casualty Actuarial Society (Courses 1-4). Admission is currently limited to forty-five students per year. The course and credit requirements are as follows (the superscript indicates credit value):

66 BA or BSc Honours in Actuarial Mathematics
30 MATH 244[3], 245[3], 251[3], 252[3], 344[3], 345[3], 354[3], 361[3]; STAT 249[3], 250[3]
24 ACTU 256[3], 257[3], 357[3], 457[3]; STAT 349[3], 360[3], 460[3], 461[3]
1 ACTU 286[1]; MATH 288[1], 289[1]; STAT 287[1]
2 ACTU 386[2], 486[2]; MATH 387[2]; STAT 388[2]
3 ACTU/MATH/STAT chosen with prior departmental approval
6 Honours project ACTU 493[6]

60 BA or BSc Specialization in Actuarial Mathematics
The same courses listed for the Honours in Actuarial Mathematics except students do not take the Honours project MATH 496[6].

Suggested Sequence of Courses **(For first- and second-year students only)**

	Term 1	Term 2	Term 3	Term 4	Term 5	Term 6
Compulsory Courses (54 credits)	ACTU 256 MATH 344 MATH 251 STAT 249	ACTU 257 MATH 345 MATH 252 STAT 250	ACTU 357 MATH 244 STAT 349	ACTU 457 MATH 245 STAT 461	ACTU 458 MATH 354 STAT 360	ACTU 459 STAT 460
Suggested Electives (36 credits)	COMP 212 COMP 248	ACTU 286* ACTU 386* STAT 287*	ACCO 230** COMM 217† ECON 201 FRAN 404 FRAN 418 MANA 266**	ACTU 486* COMM 220† ECON 203 FRAN 319	COMM 212† COMM 308† MANA 211** STAT 449 STAT 450 STAT 452	COMM 222† COMM 224† ECON 331 FINA 380
Professional Exams		Courses 1: May		Course 2: May	Course 3: November	Course 4 : May

* At least 3 credits out of these 6 is required, but at most 66 ACTU/MATH/STAT credits will count towards the Specialization. ** Part of the 15-credit cluster "The Basics of Business". † Part of the 30-credit Minor in Business Studies.

Pure & Applied Mathematics
This area provides a strong theoretical background in the core subjects of pure and applied mathematics including algebra, analysis, number theory, numerical analysis, and optimization. In addition, students learn to use a variety of mathematical tools to solve problems that arise in the physical sciences. The course and credit requirements are as follows:

66 BA or BSc Honours in Pure & Applied Mathematics
30 MATH 244[3], 245[3], 251[3], 252[3], 344[3], 345[3], 354[3], 361[3]; STAT 249[3], 250[3]
12 MATH 366[3], 369[3], 464[3], 467[3]
6 MATH 470[3] and 471[3], 474[3] and 475[3], 478[3] and 479[3]; STAT 449[3] and 452[3]
1* ACTU 286[1]; MATH 288[1], 289[1]; STAT 287[1]
2* ACTU 386[2], 486[2]; MATH 387[2]; STAT 388[2]
9 MATH/STAT chosen with prior departmental approval
6 Honours project MATH 496[6]

60 BA or BSc Specialization in Pure & Applied Mathematics
The same courses listed for the Honours in Pure & Applied Mathematics except students do not take the Honours project MATH 496[6].

*** 1- and 2-credit labs are no longer offered; students must replace them with MAST 397[3].**

Suggested Sequence of Courses

	Term 1	Term 2	Term 3	Term 4	Term 5	Term 6
Compulsory Courses (42 credits)	MATH 344 MATH 251 STAT 249	MATH 345 MATH 252 STAT 250	MATH 244 MATH 369 MATH 354	MATH 245 MATH 366 MATH 361	MATH 464 MATH 467	MATH 496*
Electives (6 credits)						MATH 470 & 471 MATH 474 & 475 MATH 478 & 479 STAT 449 & 452
Electives (1 credit)	ACTU 286	STAT 287 MATH 288 MATH 289				
Electives (2 credits)	ACTU 386	MATH 387 STAT 388				
Electives (9 credits)			**	**	**	**

* Honours project is required for Honours students.
** Courses chosen from a list of other Mathematics & Statistics electives offered.

Statistics

This area introduces the student to probability theory which underlies the mathematical structure of the random component of everyday systems such as the economy, health and survival, the weather, the stock market, and outcomes of sporting events and gambling. Students go through the elementary to advanced methods of statistical analysis of the data to be able to make decisions in the face of uncertainty. The course and credit requirements are as follows:

66 BA or BSc Honours in Statistics

30 MATH 244[3], 245[3], 251[3], 252[3], 344[3], 345[3], 354[3], 361[3]; STAT 249[3], 250[3]
12 MATH 366[3]; STAT 349[3], 360[3], 450[3]
6 MATH 464[3] and 467[3], 478[3] and 479[3]; STAT 449[3] and 452[3], 460[3] and 461[3]
1* ACTU 286[1]; MATH 288[1], 289[1]; STAT 287[1]
2* ACTU 386[2], 486[2]; MATH 387[2]; STAT 388[2]
9 MATH/STAT chosen with prior departmental approval
6 Honours project STAT 499[6]

60 BA or BSc Specialization in Statistics

The same courses listed for the Honours in Statistics except students do not take the Honours project STAT 499[6].

*** 1- and 2-credit labs are no longer offered; students must replace them with MAST 397[3].**

Suggested Sequence of Courses

	Term 1	Term 2	Term 3	Term 4	Term 5	Term 6
Compulsory Courses (42 credits)	MATH 344 MATH 251 STAT 249	MATH 345 MATH 252 STAT 250	MATH 244 STAT 349 MATH 354	MATH 245 MATH 366 MATH 361	STAT 360 STAT 450	STAT 499*
Electives (6 credits)						MATH 464 & 467 MATH 478 & 479 STAT 449 & 452 STAT 460 & 461
Electives (1 credit)	ACTU 286	STAT 287 MATH 288 MATH 289				
Electives (2 credits)	ACTU 386	MATH 387 STAT 388				
Electives (9 credits)			**	**	**	**

* Honours project is required for Honours students.
** Courses chosen from a list of other Mathematics & Statistics electives offered.

The Major in Mathematics & Statistics

There is a single Major in Mathematics & Statistics which is a 42-credit programme with a common core of 33 credits. It is aimed at students who would like to have a good background in the mathematical sciences, but whose goals are to enter the job market upon graduation, rather than to pursue graduate studies. Thus, the focus of the Major is on the applicable nature of the mathematical sciences as tools for solving, and as ways of thinking about, a wide range of problems. Certain selected topics will be covered in each course accompanied by the use of appropriate software applications. The course requirements for the programme are as follows:

42 BA or BSc Major in Mathematics & Statistics

33 COMP 248[3]; MAST 217[3], 218[3], 219[3], 221[3], 223[3], 224[3], 234[3], 235[3], 331[3], 332[3]
3 MAST 333[3], 334[3], 335[3], 397[3], 398[3]; MATH 370[3]
6 Chosen with prior departmental approval. NOTE: This category may also include any other courses in the MATH/STAT/ACTU discipline, with proper prerequisites.

Suggested Sequence of Courses

	Term 1	Term 2	Term 3	Term 4	Term 5	Term 6
Compulsory Courses (33 credits)	MAST 217 or COMP 238 MAST 218 MAST 234	MAST 219 MAST 235	COMP 248 MAST 221 MAST 224	MAST 223 MAST 332		MAST 331
Electives (3 credits)	MAST 397A		MATH 370	MAST 335	MAST 333 MAST 334	MAST 398
Electives (6 credits)	Courses	Chosen	With	Department	Approval	
	MAST 214*					

* This course is required of the students who have less than 70% in CEGEP math courses.
Note: (1) Students admitted in the Major cannot take Specialization/Honours courses unless approved by the Department;
(2) Students doing the Major in Mathematics & Statistics are encouraged to join the Minor in Computer Science (24 credits) and/or Major in MIS (24 credits).

The Minor in Mathematics & Statistics

This programme is aimed at students who are in another discipline (i.e. finance, computer science) and who would like a stronger mathematical background to complement their studies. The course requirements for the programme are as follows:

24 Minor in Mathematics & Statistics

18 MAST 217[3], 218[3], 219[3], 221[3], 223[3], 224[3]
6 MATH/STAT chosen with prior departmental approval from MAST 234[3], 235[3], 330[3], 331[3], 332[3], 333[3], 334[3], 335[3], 397[3], 398[3]

6. CAREER OPPORTUNITIES

Graduating students may use their background in mathematics as an entry to other fields. For example, students majoring in Statistics often find jobs in government agencies, the health sciences, business analysis and economics; while students specializing in Pure and Applied Mathematics are in demand in computer hardware and software companies, and in high-technology industries such as aeronautics. Of course, Actuarial graduates are always sought after by insurance companies, consulting firms, and large corporations. A career in teaching and research is also a route followed by our graduates.

Indeed, professional opportunities are available in fascinating and diverse settings. The analytical skills acquired in our Undergraduate Mathematics programme equip the student with the tools necessary for today's high-technology market.

7. CO-OPERATIVE PROGRAMMES IN ACTUARIAL MATHEMATICS, PURE & APPLIED MATHEMATICS, AND STATISTICS

Students enrolled in these programmes either follow a honours or a specialization stream in their chosen specialty. In addition, most students opt for a minor in a complementary discipline such as accountancy, business administration, computer science, finance, management or other fields of interest.

The Co-op Admission Process

Co-op students are usually admitted in September, after obtaining their CEGEP diploma. In some cases, they are also admitted in January if their academic and professional profiles make it easy for them to integrate into the regular work-study pattern of their programme. The criteria for admission into a co-op programme in the Department of Mathematics and Statistics include academic excellence and work experience. Admission is a two-stage process: In order to be eligible for co-op, students must have already been admitted to the University. The Department then selects suitable candidates through a personal interview process. Students are invited for an interview if their academic record and the additional material that they submit are considered promising. If found suitable, students are recommended to the Institute for Co-operative Education for admission to their chosen programme. In order to be admitted into a co-operative programme, students must demonstrate that, in addition to academic excellence, they possess or can acquire quickly the language, writing, computing, and interpersonal skills required by employers. The number of places in the programmes is limited by the identified opportunities for employment at a given time and by the resources available within the University to provide students with suitable professional guidance and support.

Academic Achievements

Over the years, co-op students in Actuarial Mathematics, Pure and Applied Mathematics, and Statistics have proven to be among Concordia's best graduates. They invariably receive awards and medals for their academic achievements and the Dean's Honour Roll is usually speckled with the names of these students.

Work Terms

The co-operative programmes in Actuarial Mathematics, Pure & Applied Mathematics, and Statistics involve four compulsory work terms, each lasting at least twelve weeks. For students entering a first-year university programme in September, the first work term begins in May of the next calendar year. After that, students alternate work and study terms. At the end of a work term, they must write and are graded on a work-term report. Although the University maintains a network of employers and makes every effort to help students find work term placements, it is up to the students to convince employers in interviews to hire them as full-time employees for a work term. Students on a work term are considered full-time employees and are paid a regular salary commensurate with their level of seniority.

Who hires Co-op Students?

The Department's network of employers of co-op students includes the private sector, consulting firms, insurance companies, R&D based companies, software companies, and research organizations, as well as the Quebec and other provincial governments, and the federal government. Concordia Co-op students are regularly employed in major Canadian cities from Halifax to Vancouver as well as in the US, England, France, Australia, and other countries. Employers hire Mathematics Co-op students for two main reasons: because they need bright people with good analytical skills and problem-solving experience to fill short-term vacancies; and to engage in a risk-free search for future employees. Some companies actually consider co-op graduates to be their most valuable human resource. Several employers are themselves graduates of a Concordia co-op programme and are enthusiastic supporters of the next generation of co-op students.

The Co-op Curriculum

Co-op students in Mathematics and Statistics follow the regular academic programmes in their area. Specialized courses are sometimes available on a tutorial basis if needed. Students in Actuarial Mathematics, on the other hand, follow a discipline-based curriculum. It includes workshops that prepare the students for external professional examinations.

The Employability of Co-op Graduates

Many employers have discovered that even in non-mathematical fields, Mathematics graduates with good professional skills are among their most valuable employees. Because of the integration of the co-op curriculum into the regular mathematics streams, graduates of the Actuarial Mathematics, Pure & Applied Mathematics, and Statistics co-op programmes at Concordia University have demonstrated consistently that they possess superior analytical, problem-solving, and organizational skills, and have excellent employment prospects.

8. STUDENT ADVISING AND THE MATHEMATICS HELP CENTRE

All students in the Mathematics & Statistics programme can call the Department's main offices and ask to see an academic advisor at any time during the semester. Every student entering a Honours/Specialization programme is encouraged to see a full-time faculty member who will act as their academic advisor and mentor throughout the programme. General advising seminars are organized for newly admitted students and usually take place during the months of May, August and December.

The Department also runs a Mathematics Help Centre staffed by graduate students and final-year undergraduates. The Help Centre provides tutoring and personal assistance for students (particularly for first-year courses), and helps to smooth the transition from CEGEP to university.

9. MATHEMATICS & STATISTICS ASSOCIATION (MASA)

MASA is a student organization which functions as a support group for newly-admitted as well as returning students. They organize seminars on popular themes in mathematics and publish a newsletter called "The Irrational". Their office is located on the Loyola campus (HB 326) and they can be contacted by telephone at 848-3268 or by e-mail at masa@alcor.concordia.ca. Interested students can find their web page on http://cug.concordia.ca/~masa/.

10. LIST OF COURSES*

Actuarial Mathematics

ACTU 256 Mathematics of Finance (3 credits)
Measurement of interest; annuities and perpetuities; amortization and sinking funds; rates of return; bonds and related securities; life insurance.

ACTU 257 Actuarial Mathematics I (3 credits)
Measurement of mortality; survival function, mortality tables, force of mortality; special topics.

ACTU 286 Actuarial Math Lab I (1 credit)
This lab will feature problem-solving sessions for the general Mathematics examination of the Society of Actuaries and the Casualty Actuaries Society.

ACTU 357 Actuarial Mathematics II (3 credits)
Life annuities; pure endowments, annual payments, continuous annuities, net annual premium, net level premium reserves; the expense factor; special topics.

ACTU 386 Actuarial Math Lab II (2 credits)
This lab will feature the use of the language APL or other suitable computer software for actuarial students.

ACTU 456 Pension Mathematics (3 credits)
Valuation methods; gains and losses; dynamic control; special topics.

ACTU 457 Risk Theory (3 credits)
Applications of contingency theory in life and health insurance, annuities and pension; individual risk theory, ruin theory.

ACTU 458 Credibility Theory (3 credits)
Credibility approach to inference for heterogeneous data; classical, regression and Bayesian models; illustrations with insurance data.

ACTU 459 Loss Distributions (3 credits)
Probability model fitting to loss data; estimation and testing under a variety of procedures and sampling designs.

* Prerequisites, notes and equivalents are stipulated in the U/G Calendar.

ACTU 486 Actuarial Math Lab III (2 credits)
This lab is a workshop designed to prepare students for the Actuarial Mathematics examinations of the Society of Actuaries and the Casualty Actuaries Society.

ACTU 491 Topics in Actuarial Mathematics (3 credits)

ACTU 492 Reading Course in Actuarial Mathematics (3 credits)

ACTU 493 Honours Project in Actuarial Mathematics (6 credits)

Mathematics & Statistics

MAST 214 Calculus and Linear Algebra (6 credits)
Functions; maxima and minima. Velocity and acceleration. Iterative solution of equations, parametric equation of curves. Integrals; change of variables, integration by parts, double integrals, numerical integration. Conic sections. Matrices, determinants, eigenvalues, eigenvectors, system of equations. Series and their convergence. Introduction to vector space and complex numbers. Word problems.

MAST 217 Introduction to Mathematical Thinking (3 credits)
This course aims to foster analytical thinking through a problem-solving approach. Topics will include construction of proofs, number systems, ordinality and cardinality, role of examples and counter examples, role of generalizations and specializations; role of symbols, notations and definitions; styles of mathematical discourse.

MAST 218 Multivariable Calculus I (3 credits)
Vector geometry; lines and planes; curves in R^n; vector functions; vector differential calculus; extrema and Lagrange multipliers. Introduction to multiple integrals and coordinate transformations. Problem solving with MAPLE.

MAST 219 Multivariable Calculus II (3 credits)
Vector integral calculus; line and surface integrals; Green's, Stokes' and Gauss' theorems; coordinate transformations and Jacobians. Power series, applications. Problem solving with MAPLE.

MAST 221 Applied Probability (3 credits)
Counting rules, discrete probability distributions; random sampling; conditional probabilty; means and variances, normal and other continuous sampling distributions. Applications. Use of MINITAB and/or SYSTAT.

MAST 223 Introduction to Stochastic Methods of Operations Research (3 credits)
Markov chains; queuing theory; inventory theory; Markov decision processes; applications to reliability.

MAST 224 Introduction to Optimization (3 credits)
Introduction to the theory of optimization; linear programming; the simplex method; duality and transportation problem. Introduction to graphs and networks; applications. Use of computing softwares.

MAST 234 Linear Algebra and Applications I (3 credits)
System of linear equations, matrix operations, echelon forms and LU-factorization; R^n: subspaces, linear dependence, basis, dimension, matrix transformations; eigenvalues and eigenvectors in R^n and applications (e.g. Markov chains, dynamical systems). The software MAPLE will be extensively used.

MAST 235 Linear Algebra and Applications II (3 credits)
R^n: Orthogonality, projections, Gram-Schmidt method and QR-factorization; applications to least square methods (data fitting, inconsistent systems). Symmetric matrices, principal axes theorem and applications. Special topics (e.g. coding theory, differential equations, error analysis). The software MAPLE will be extensively used.

MAST 330 Differential Equations (3 credits)
First-order differential equations; second-order differential equations; Laplace transform methods; mathematical models and numerical methods.

MAST 331 Mathematical Modelling (3 credits)
Introduction to mathematical modelling; predator-prey models in biology, game theory, decision analysis, stability theory; modelling electric circuits.

MAST 332 Introduction to Mathematical Computing (3 credits)
This course is an application-oriented introduction to symbolic computation, as it applies to algebra, number theory and combinatorics covering the following topics: capabilities of symbolic systems (i.e. MAPLE), modular methods, arithmetic mod p, arithmetic mod m, matrices mod p, Chinese remainder theorem, polynomial factorization mod p. applications to coding theory and cryptography. Combinatorial algorithms.

MAST 333 Applied Statistics (3 credits)
Graphical and numerical descriptive methods; estimation and hypothesis testing; linear regression and correlation; one way ANOVA; contingency and goodness of fit tests. Use of statistical software e.g. MINITAB or SYSTAT.

MAST 334 Numerical Analysis (3 credits)
Introduction to computing softwares; numerical solution of non-linear equations; interpolations and approximations; quadrature and numerical integration.

MAST 335 Investment Mathematics (3 credits)
Simple and compound interest; annuities; amortization and sinking funds; mortgage schemes; bonds and related securities; capital cost and depletion; spread-sheet implementation.

MAST 397 Topics in Mathematics and Statistics (3 credits)

MAST 398 Reading Course in Mathematics and Statistics (3 credits)

Pure & Applied Mathematics

MATH 244 Analysis I (3 credits)
Mathematical rigour: proofs and counter-examples; quantifiers; number systems; Cardinality, decimal representation, density of the rationals, least upper bound. Sequences and series; review of functions, limits and continuity.

MATH 245 Analysis II (3 credits)
Connectedness and compactness in the reals. Intermediate value theorem; extreme values for continuous functions. Differential and integral calculus; fundamental theorem of calculus; power series.

MATH 251 Linear Algebra I (3 credits)
Matrices and linear equations; vector spaces; bases, dimension and rank; linear mappings and algebra of linear operators; matrix representation of linear operators; determinants; eigenvalues and eigenvectors; diagonalization.

MATH 252 Linear Algebra II (3 credits)
Characteristic and minimum polynomials; invariant subspaces, invariant direct sums; nilpotent operators, Jordan canonical form; cyclic subspaces; rational canonical form; bilinear and quadratic forms; inner product; orthogonality; adjoint operators and orthogonal operators.

MATH 288 Math Lab I (1 credit)
This lab will be associated with MATH 244 and 245.

MATH 289 Math Lab II (1 credit)
This lab will be associated with MATH 251 and 252.

MATH 334 Combinatorics (3 credits)
General principles of counting, permutations, combinations, identities, generating functions; Fibonacci numbers; partitions, recurrence relations, Stirling numbers, Catalan numbers, principle of inclusion-exclusion, cycles of permutation, orbits of permutation groups, parity of a permutation, Polya's theorem.

MATH 344 Analysis III (3 credits)
Sequences and series of functions, including uniform convergence of functions. Multivariable calculus; the derivative as a linear approximation. Matrix representation; gradients, chain rule, tangent space and mean value theorems; maxima and minima including Lagrange multipliers; inverse and implicit function theorem.

MATH 345 Analysis IV (3 credits)
Multiple integrals; integrals over regions in R^n; curves and surfaces including parametric representations; a short introduction to manifolds in R^n; integrals on surfaces, versions of Stokes' theorem.

MATH 352 Linear Algebra III (3 credits)
Matrices, linear transformations, determinants, metric concepts, inner-product spaces, dual spaces, spectral theorem, bilinear and quadratic

forms, canonical forms for linear transformation, matrix functions, selected topics.

MATH 354 Numerical Analysis (3 credits)
Error analysis in numerical algorithms; solution of non-linear equations; fixed point iterations, rate of convergence. Interpolations and approximations, Legendre polynomials. Numerical integration and quadrature.

MATH 361 Operations Research I (3 credits)
Introduction to the theory of optimization; linear programming, simplex method; revised simplex method; transport and assignment problems; integer programming; introduction to graphs and networks.

MATH 366 Complex Analysis I (3 credits)
Algebra and geometry of complex numbers, linear transformations, analytic functions, Laurent's series, calculus of residues, special functions.

MATH 369 Abstract Algebra I (3 credits)
Introduction to algebraic systems; groups, rings, fields, homomorphisms.

MATH 370 Ordinary Differential Equations (3 credits)
Separable equations, exact equations, integrating factors, force fields, first-order linear equations, input-output concept, second-order equations, Sturm-Liouville problems, applications, series solutions, reduction of order, variation of parameters, nth-order linear equations with constant coefficients, Laplace transforms, block diagrams, and signal flow graphs.

MATH 371 Partial Differential Equations (3 credits)
Canonical forms for second-order linear equations with constant coefficients, classification of linear second-order equations, method of separation of variables, first-order PDE's, method of characteristics. Non-linear first-order equations, complete integrals, Cauchy conditions, Cauchy-Kowalewski theorem, Fourier and Laplace transforms, Green's functions, integral representations, introduction to non-linear PDE's.

MATH 380 Differential Geometry (3 credits)
Calculus on Euclidian spaces, tangent vectors, directional derivatives, differential forms, mappings, curves, frame fields, Serret-Frenet formulas, covariant derivatives; calculus on a surface, tangent spaces, differential forms on a surface, mappings between surfaces, integration of forms, Stokes' theorem.

MATH 387 Math Lab III (2 credits)
This lab will demonstrate the use of MAPLE software for Calculus, Linear Algebra, and Statistics.

MATH 392 Elementary Number Theory (3 credits)
Number systems, division and factorization, number-theoretic functions, congruences, algebraic congruences and primitive roots, quadratic residues, diophantine equations.

MATH 397 History of Mathematics (3 credits)
Early mathematics, Greek mathematics, European mathematics in the Middle Ages, the origin and development of analytic geometry and calculus, mathematics as free creation, the generality of mathematics in the twentieth century.

MATH 433 Calculus of Variations (3 credits)
Nature of problems, weak variations, the first variation, Euler's equation. The second variation, Jacobi's equation, Legendre's test, conjugate points. Relative maxima and minima, iso-perimetrical problems. Integrals with variable end points. Applications to problems in pure and applied mathematics; the principle of least action. Strong variations, the Weierstrass E-function.

MATH 464 Real Analysis (3 credits)
Metric spaces; function spaces; compactness, completeness, fixed-point theorems, Ascoli-Arzela theorem, Weierstrass approximation theorem.

MATH 466 Complex Analysis II (3 Credits)
Cauchy's theorem, singularities, maximum modulus principle, uniqueness theorem, normal families, Reimann mapping theorem.

MATH 467 Measure Theory (3 credits)
Lebesgue Measure and Integration on the real line, convergence theorems, absolute continuity, completeness of $L^2[0,1]$.

MATH 470 Abstract Algebra II (3 Credits)
Normal subgroups, quotient groups, isomorphism theorems, polynomial rings, principal ideal rings, elementary field theory.

MATH 471 Abstract Algebra III (3 Credits)
Sylow theorems, composition series, ideal theory of rings, Noetherian rings, modules.

MATH 472 Abstract Algebra IV (3 Credits)
Elements of field and Galois theory, including straight-edge-and-compass construction and unsolvability of equations of fifth degree by radicals.

MATH 474 Linear and Nonlinear Dynamical Systems (3 Credits)
Systems of linear differential equations; fundamental matrices; non-homogeneous linear systems; non-linear systems; solutions and trajectories; the phase plane; stability concepts; Liapounov's second method; periodic solutions and limit cycles; introduction to boundary-value problems and Sturm-Liouville theory.

MATH 475 Discrete Dynamical Systems, Chaos and Fractals (3 Credits)
Introduction to discrete dynamical modeling; periodic points; bifurcation; period three points; symbolic dynamics; chaos; transitivity; conjugacy; complex behaviour; introduction to fractals; computer simulations.

MATH 478 Non-linear Programming (3 Credits)
Classical methods of optimization, Lagrange multipliers, Kuhn-Tucker conditions; line search methods, quadratic programming, gradient methods, introduction to dynamic programming.

MATH 479 Convex and Nonlinear Analysis (3 Credits)
Support and separation of convex sets, extreme point characterizations, convex and dual cones, Farkas' theorem; minimax theorem of Game Theory, Legendre-Fenchel conjugate, infimal convolution, subgradient calculus; Lagrangians, necessary and sufficient conditions for optimality in constrained minimization; the dual problem.

MATH 494 Topics in Pure and Applied Mathematics (3 credits)

MATH 495 Reading Course in Pure and Applied Mathematics (3 credits)

MATH 496 Honours Project in Pure and Applied Mathematics (6 credits)

Statistics

STAT 249 Probability I (3 credits)
Axiomatic approach to probability; combinatorial probability; discrete and continuous distributions; expectation; conditional expectation; random sampling and sampling distributions.

STAT 250 Statistics (3 credits)
Point and interval estimation; hypothesis testing; Neyman Pearson Lemma and likelihood ratio tests; introduction to correlation and regression.

STAT 287 Stat Lab I (1 credit)
This lab will be associated with courses STAT 249 and 250 and will be helpful for the Probability and Statistics examinations of the Society of Actuaries and the Casualty Actuaries Society.

STAT 342 Industrial Statistics (3 credits)
Concepts of statistical quality control; X-bar R, P, and C control charts, acceptance sampling, sampling inspection, continuous sampling plans.

STAT 343 Sample Survey Theory and Applications (3 credits)
Basic sampling designs and estimators; simple random sampling, stratified, cluster and systematic sampling. Sampling with unequal probabilities; ratio and regression methods of estimation.

STAT 347 Introduction to non-parametric Statistics (3 credits)
Theory of rank tests, sign test, Mann-Whitney and Wilcoxon one-sample and two-sample tests, Kruskal-Wallis test; goodness of fit tests, Kolmogorov-Smirnov test, Pearson chi-square test, rank correlation and Kendall's tau.

STAT 349 Probability II (3 credits)
Markov decision process and applications. Poisson process, queuing theory, inventory theory; applications.

STAT 360 Linear Models (3 credits)
Least-squares estimators and their properties. General linear model with full rank. Analysis of residuals; adequacy of model, lack of fit test, weighted least squares; stepwise regression, Durbin-Watson statistic; one-way and two-way analysis of variance.

STAT 388 Stat Lab II (2 credits)
This lab will use various available softwares such as SYSTAT, SAS, SPLUS, MINITAB for data analysis.

STAT 449 Advanced Probability (3 credits)
Central limit theorems and law of large numbers, convergence of random variables, characteristic function, moment generating function, probability generating functions, random walk and reflection principle.

STAT 450 Mathematical Statistics (3 credits)
Derivation of standard sampling distributions; distribution of order-statistics; estimation, properties of estimators; Rao-Cramer inequality, Rao-Blackwell theorem, maximum likelihood and method of moments estimation, Neyman-Pearson theory, likelihood ratio tests and their properties.

STAT 452 Introduction to Stochastic Processes (3 credits)
Continuous stochastic processes. Poisson processes, continuous time Markov process, queuing models, birth and death processes, renewal theory.

STAT 460 Time Series and Forecasting (3 credits)
Time series, forecasting by trend and irregular components (using multiple regression analysis and exponential smoothing); forecasting seasonal time series, additive and multiplicative decomposition methods, Box-Jenkins methodology, moving average, autoregressive and mixed models.

STAT 461 Operations Research II (3 credits)
Dynamic programming, renewal theory and applications, system reliability; simulation and Monte-Carlo techniques; network analysis.

STAT 465 Multivariate Statistics (3 credits)
Multivariate normal distribution; estimation and testing of hypothesis about mean vector; multiple and partial correlation; MANOVA; principal components analysis.

STAT 468 Design of Experiments (3 credits)
Construction and analysis of standard designs, including balanced designs; block designs; orthogonal designs; response surface designs.

STAT 480 Statistical Data Analysis (3 Credits)
The analysis of real life data sets using computer packages. Topics will involve techniques from generalized linear models; model selection; log-linear models for categorical data analysis; logistic regression; censored survival models.

STAT 497 **Topics in Statistics (3 credits)**

STAT 498 **Reading Course in Statistics (3 credits)**

STAT 499 **Honours Project in Statistics (6 credits)**